GROMIT: A Tool for Systems Ethnography

GROMIT (Graphical Representation Ontology Modeling Inference Tool) is a software package developed by the Statistical Sciences Group (D-1) at Los Alamos National Laboratory. It is part of the System Ethnography and Qualitative Modeling (SEQM) team's effort to advance research in socio-technical systems representations and system statistical reliability analysis. GROMIT supports system analysis by providing a robust, compact and dynamic graphical language to describe complex system structure. GROMIT forces a consistent integration of information on component composition with behaviors and then uses this rigorous foundation to infer system-wide behaviors from observed and/or elicited data.

Why is GROMIT being developed?

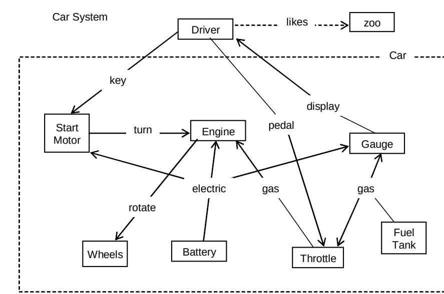
GROMIT supports the development of statistical reliability models of complex systems for which no single individual has a complete understanding. It does this by:

❖Capturing hypotheses from all system stakeholders about what components exist in the system, and how those components relate to one another;
❖Encoding component behaviors as a set of rules which can be tested against observed system behaviors;
❖Incorporating dynamic system behaviors across all operational modes of the system;
❖Linking component state information to quantitative and qualitative data sources;
❖Performing checks to determine whether component reliability hypotheses are consistent and result in calculable reliability models; and
❖Inferring all possible combinations of component states that can result in observed system behaviors.

Our initial thrust is to describe the logic and structure of statistical system models by making use of all available system data, whether qualitative or quantitative. However, the longer term goal of the SEQM team is to advance the ability of planners to successfully deploy and operate complex systems within culturally, physically and politically defined constraints.

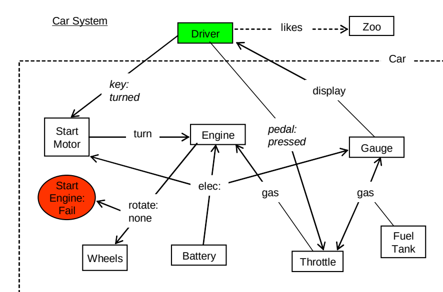
GROMIT in use:

A key function of GROMIT is to generate all possible scenarios – combinations of entity states – consistent with a given set of observations (which in SEQML are encoded as events). Each of these scenarios may then be explored by the ethnographer individually in order to gain further insight into the system. Consider the following example, where we want to understand all possible outcomes of the event of having the driver attempt to start a car. Assume each entity in this simple system has two states: functional and non-functional.



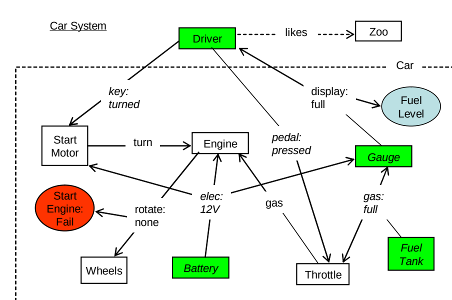
The following diagram describes a possible set of ICOM relationships which may describe our car system under a particular system behavioral state, as well as how GROMIT and SEQML work in helping understand how entities are behaving:

Suppose the driver attempts to start the engine, but it fails to start as observed by the lack of wheel rotation. What do we know about the behavior and states of the components in the system?



First let us assume that the driver is knowledgeable. From this GROMIT infers (using the rules for a functional driver) that the channel "key" should be qualified with the ICOM "turned," and the channel pedal should be qualified with "pressed." Second, we observed that the wheels have failed to rotate, which is also our definition of "Start Engine: Fail."

A number of possible scenarios must be considered to explain this behavioral pattern. Perhaps the start motor is not functional. Perhaps the engine is not functional. Perhaps the engine is functional, but a lack of fuel keeps the car from running. Or perhaps the battery is dead. In fact, there are 2^5-1 or 31 possible explanatory scenarios, given described system structure and states that GROMIT will identify. Each of these scenarios (define later) is consistent with the behaviors we are presently capable of observing.



Supposing now that we change the system, such that we (as outside observer to the system) can read the fuel gauge. Also assume that we know (and have programmed this behavior into the gauge entity) that if the gauge is not receiving power, or has failed, that it will always measure the fuel tank as "empty." This implies the representation on the right.

In this case, we have added significantly to our information set about the system, and the number of scenarios generated by GROMIT will be much reduced. Because the gauge measures "full," GROMIT can infer that it is functional, that the battery must be supplying 12v power, and that the fuel tank is full. Based on this information, GROMIT will calculate a set of 2^3-1 or 7 possible scenarios involving the start motor, engine, and throttle that are consistent with our observations (failed engine start, functional driver, and full gas tank). Note that information inferred from entity behavior rules is italicized.

This example points out two important ideas behind the development of GROMIT. First, although in the simple, largely parallel, example presented here it is quite possible to readily identify all possible scenarios by hand, this is not the case for all but the most simple and small systems. GROMIT's analysis of system logic can extend across multiple representations and can trace possible combinations of states across much more complicated chains of ICOMS than are presented in this example. Second, this example can be used to point out one of the great strengths of the GROMIT tool: that it forces the user to be explicit about what is actually known about the system and what is not.

In the above example, because of our limited ability to measure what happens inside the car, from a causality standpoint we have a very difficult time identifying the exact failure entity or entities responsible for the failure of the car to start as anticipated. However, we can identify what components are **not** responsible, we can assay how many failure scenarios are removed from consideration with the addition of measurements (such as the gauge reducing the scenario set from 31 to 7 combinations) and we can determine correlation patterns of entities related to particular failures. In the context of complex system management and prediction, this has great implications for experimental design and failure cause diagnosis.

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